Ascertaining Unknown Organic Compounds

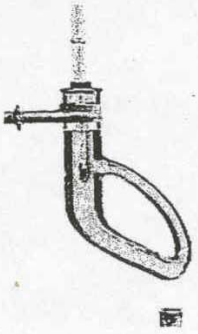
M G
AP Chemistry

Introduction

Compounds are distinguishable by certain unique properties, either chemical or physical. A physical property is one in which the chemical makeup is unchanged, for example, color, melting point, and boiling point. On the other hand, a chemical property is one where the chemical makeup *is* changed, such as heat of combustion, pH, and reactivity with water (1). Knowing properties of compounds allows for identification as well as the conduct of the compound under various situations.

When given six unknown organic compounds and one unknown organic mixture, labeled A through G, their chemical and physical properties will be the basis of identification. This required research in order to familiarize with the given possible compounds as well as any irregularities that may be observed. The possible compounds ranged from acids such as Propionic and Stearic to sucrose and sulfanilamide, but physically, all looked similar. The most discernible property was the melting point, which was used as the first step in classifying the compounds. The more properties determined about the unknown compounds, the more accurate the identification. Solubility and pH helped conclude the final classification of the unknown compound.

Figure 1: *The Theile Tube and thermometer setup containing capillary tubes with about .5 cm of the unknown compounds was used to experimentally determine the melting point (2).*



Experimental Procedure

Melting points were ascertained using a Theile Tube Oil Bath as seen in Figure 1. Around a half-centimeter of the ground compounds were placed in the capillary tubes that were then attached to the thermometer. The oil was heated by a Bunsen Burner and was able to reach temperatures of more than 200 °C. Data for this experiment were taken in ranges recorded from the temperature that the compound first began to melt until it was completely melted. The experimental results were found after multiple trials to confirm the most accurate experimental data.

In order to find the acidity of the compounds, 20 milliliters of distilled water (pH of 5) was combined in a beaker with .15 grams of the compounds. The acidity was then checked by pH strips that matched the respective acidity color. Multiple tests with new solutions were performed if there was no definite matching color.

Compound B was the only compound on which a solubility test was performed. This test was performed in order to differentiate two possible compounds using a solution of alcohol and compound. The solubility of the compound in the alcohol would determine which possible compound was Compound B.

Results

Each compound was given in a solid state, all of which had a white, crystal-like physical appearance. Some were flakier, about .3 - .5 centimeters in diameter, but most had significantly smaller widths, nearly resembling salt and sugar. When melted, all liquefied clearly and returned to a solid as the oil was then cooled. In creating a solution for the acidity tests, most were still not completely dissolved; they were broken up, but the solvent remained visible. The results for these experiments are displayed in Figure 2.

Since the objective is to determine which compounds are which, the melting point results were first compared to the researched and accepted values. Judgements were based on a range of about ± 5 °C and very few compounds were identified from this step alone. Figure 3 shows each compound with its respective possibilities

to this point. Acidity will prove to be the determining property for majority of the compounds.

Figure 2: *The experimental melting points are given in ranges from the temperature the compound began melting to its completion. Acidity was distinguished using pH strips and matching coordinating colors.*

Compound	Exp. Mp	Acidity
A	117-125	2
B	143-145	1
C	133-135	5
D	45-47	6
E	195-200	2
F	160-165	2
G	40-45, 145-148	3

Figure 3: *Based on the melting points determined in research and experimentally, most unknowns still remain uncertain after one property had been tested and compared. The final classifications are highlighted in blue font.*

Compound	Possible Compounds
A	Benzoic Acid
	Acetanilide
B	Malonic Acid
	Maleic Acid
C	Urea
	Malonic Acid
D	Lauric Acid
E	Ascorbic Acid
	Sucrose
F	Salicylic Acid
	Sulfnilamide
G	Maleic Acid & Lauric Acid

Using the data presented in Figure 2 with the possible choices in Figure 3, further conclusions can be drawn. Benzoic Acid can be identified as Compound A for it is accepted to have a pH of 2.8 compared to the experimental value of 2 (3). Compound C, pH of 5, that of water, has little to no acidity and therefore eliminates Malonic Acid and classifying Urea as the compound. Both Compounds E and F are extremely acidic, thus inferring the compounds as Ascorbic and Salicylic Acids respectively.

The Mixture G was resolved based solely on the melting points. From experimental data and the research, Maleic Acid and Lauric Acid match, but the accuracy of this accusation is low due to the variation observed. Due to time constraints, this was only tested twice, each time with again, a large, very noticeable difference. Since this was a mixture, the two compounds should melt at their individual temperature. This allows for one to be in a solid state while the other has melted and is a liquid. Not until the temperature reaches the melting point of the solid will the mixture be a complete solid. Both times tested, this was not the case.

The remaining compound, Compound B, required an extra step in the identification process since both the melting points and pH of Malonic and Maleic Acid are so similar. The solubility tests in alcohol proved Compound B to be Malonic Acid.

Discussion

In completing this experiment, accuracy throughout was key. Not only did the temperatures and pH have to be precise but accuracy also depended on how many properties were identifiable. Having a list of possibilities was fortunate enough, but the process still proved arduous. Using the process of elimination is acceptable for this task, but identifying any compound out of the blue, as crime scene investigator or poison center may, would required further tests on even more properties to best identify the compound or substance.

Accuracy, however, could have easily been lost at many points throughout the process. Mixture G still causes question since compounds may have been mixed up when changing the capillary tube. Yet, since it is a mixture, there could have been different proportions of each compound in the two samples melted. Also, it is possible that the compound was dissolved in the liquid and therefore making it nearly impossible to tell when the dissolved compound would melt. In the acidity tests, the general ratio of .15 gram compound to 20 milliliter very easily could have caused incorrect amounts of each to most precisely find the acidity. If the compound dissolves with minimal water, 20 milliliters would over-saturate it making the pH read closer to that of water.

The problem solving aspect of science is hinged on the ability to test discernable properties and explore the unknown in a variety of ways. As Charles Sanders Pierce stated, "There is one thing even more vital to science than intelligent methods; and that is, the sincere desire to find out the truth, whatever it may be," (4). Other properties such as boiling point and reactivity with other compounds would also have proven beneficial and accurate. However, finding any such property through research can be just as difficult as the identification process, deepening that sincere desire.

Literature Cited

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